CLAIMS

1. A method for encoding multiple blocks in a frame of image data, comprising:

identifying a target bit value equal to a total number of bits available for encoding the frame;

predicting a total distortion in the frame according to quantization values assigned to each one of the blocks, the quantization values characterized according to an amount of energy in each block and a number of bits assigned to each block;

adapting optimum quantization values for each of the multiple blocks by minimizing the total predicted distortion in the frame subject to a constraint that the total number of bits available for encoding the frame is equal to the target bit value; and

encoding the blocks with the predicted optimum quantization values.

2. A method according to claim 1 wherein the optimum quantization values are generated using a Lagrange optimization on the predicted total distortion.

3. A method according to claim 1 wherein the optimum quantization values are derived according to the following,

$$Q_i^* = \sqrt{\frac{AK}{(B-ANC)}\frac{\sigma_i}{\alpha_i}\sum_{k=1}^{N}\alpha_k\sigma_k} ,$$

where, Q_i^* is the optimum quantization value for each block i, N is the number of blocks in the frame, B is the total number of bits available for encoding the frame, A is a number of pixels in each of the multiple blocks, K and C are constants associated with the image blocks, σ_i is an empirical standard deviation of pixel values in the block, and α_i is a weighting incorporating the importance of distortion in the block.

4. A method according to claim 1 including adjusting the optimum quantization values according to a number of image blocks remaining to be encoded and a number of bits still available for encoding the remaining image blocks.

5. A method according to claim 3 including using a K parameter and a C parameter on a block-by-block basis to adjust the optimum quantization values for each of the multiple blocks, the K parameter modeling correlation statistics of the pixels in the image blocks and the C parameter modeling bits required to code overhead data.

6. A method according to claim 5 including deriving the optimum quantization values in either a fixed mode where the K and C parameters are known in advance or an adaptive mode where the K and C parameters are derived according to the K and C parameters of previously encoded blocks.

7. A method according to claim 6 wherein the adaptive mode includes the following steps:

deriving values for the K and C parameters that exactly predict the number of bits B used for encoding previous blocks;

deriving averages for the derived K and C parameters for the previously encoded video blocks; and

predicting the K and C parameters for a next video block by linearly weighting the average K and C parameters according to the initial estimates for the K and C parameters.

8. A method according to claim 7 wherein the values of K and C that predict B are,

$$\hat{K}_i = \frac{(B'_i - A\ C_i)Q^{*2}_i}{A\sigma_i^2} \text{ and } \hat{C}_i = \frac{B'_i}{A} - K_i\frac{\sigma_i^2}{Q^{*2}_i},$$

$$\text{or } \hat{K}_i = \frac{B'_{DCT,i}Q^{*2}_i}{A\sigma_i^2} \text{ and } \hat{C}_i = \frac{B'_i - B'_{DCT,i}}{A}$$

where $B'_{DCT,i}$ is a number of bits spent for the DCT coefficients of the current image block;

the averages of K and C are;

$$\widetilde{K}_i = \frac{i-1}{i}\widetilde{K}_{i-1} + \frac{1}{i}\hat{K}_i \text{ and } \widetilde{C}_i = \frac{i-1}{i}\widetilde{C}_{i-1} + \frac{1}{i}\hat{C}_i \text{ ; and}$$

the linearly weighted averages of K and C are,

$$K_{i+1} = \frac{i}{N}\widetilde{K}_i + \frac{N-i}{N}K_1 \text{ and } C_{i+1} = \frac{i}{N}\widetilde{C}_i + \frac{N-i}{N}C_1.$$

9. A method according to claim 3 wherein the amount of energy in the frame is not determined in advance and is estimated according to the following where,

$$Q^*_i = \sqrt{\frac{AK_i}{\left(\widetilde{B}_i - AN_iC_i\right)}\frac{\sigma_i}{\alpha_i}S_i},$$

where,

$$S_i = \sum_{k=1}^{N}\alpha_k\sigma_k,$$

and the α_K's and σ_K's are those obtained for the blocks in a previously encoded video frame.

10. A method according to claim 9 including encoding the image blocks several times to estimate parameters $K_1, K_2, \ldots K_n$ and $C_1, C_2, \ldots, C_n$ for each of the image blocks and then deriving a super optimum quantization value by setting:

$$Q_i^* = \sqrt{\frac{A\sqrt{K_i}}{\left(\tilde{B}_i - A\sum_{i=1}^{N} C_i\right)} \frac{\sigma_i}{\alpha_i} S_i},$$

where, $S_1 = \sum_{k=1}^{N} \sqrt{K_k}\sigma_k\alpha_k$ and $S_{i+1} = S_i - \sqrt{K_i}\sigma_i\alpha_i$.

11. A method according to claim 1 including predicting optimum quantization values for each frame according to the following steps:

identifying a multiframe bit value equal to a total number of bits available for encoding multiple frames;

modeling a total amount of distortion in the multiple frames according to quantization values assigned to each one of the frames, the quantization values characterized according to an amount of energy in each frame and a number of bits assigned to each frame;

predicting optimum quantization values for each frame that minimize the total modeled distortion in the multiple frames; and

encoding each frame with the predicted optimum quantization value.

12. A method according to claim 1 including applying weighting factors to each of the optimum quantization values according to location of the blocks in the frame.

13. A method according to claim 1 including controlling a number of different optimum quantization values assignable to the blocks by assigning the same quantization values to blocks having similar standard deviation values.

13. A method according to claim 1 including controlling a number of different optimum quantization values assignable to the blocks by assigning the same quantization values to blocks having similar standard deviation values.

14. A method according to claim 13 wherein the optimum quantization values are controlled by assigning the following weighting values,

$$\alpha_i = \begin{cases} 2\dfrac{B}{AN}(1-\sigma_i)+\sigma_i & \dfrac{B}{AN} < 0.5 \\ 1 & \text{otherwise} \end{cases},$$

where B/(AN) is the bit rate in bits per pixel for a current frame, B is the number of bits available, A is a number of pixels in the block, N is the total number of blocks in the frame, and σ_i is the standard deviation for the pixels in the blocks.

15. A method for quantizing regions in a video image, comprising:

receiving image information for different regions;

predicting an amount of distortion created in the video image according to quantization values assigned to the regions, the predicted distortion characterized according to the amount of information in the region and the number of bits available for encoding the information in the regions into the quantization values;

optimizing the quantization values assigned to the regions so that the amount of predicted distortion in the regions is minimized for the number of available bits; and

encoding the regions with the optimized quantization values.

16. A method according to claim 15 wherein the optimized quantization values are derived as follows,

$$Q_i^* = \left(\frac{K A_i^{\frac{\gamma}{\gamma+2}}}{\tilde{B}_i - C\sum_{n=i}^{N} A_n} \frac{\sigma_i^{\phi\frac{\gamma}{\gamma+2}}}{\alpha_i^{2\frac{\gamma}{\gamma+2}}} S_i \right)^{\frac{1}{\gamma}},$$

where,

$$S_1 = \sum_{n=1}^{N} (A_n \sigma_n^{\phi})^{\frac{2}{\gamma+2}} \alpha_n^{\frac{2\gamma}{\gamma+2}},$$

$$S_{i+1} = S_i - (A_i \sigma_i^{\phi})^{\frac{2}{\gamma+2}} \alpha_i^{\frac{2\gamma}{\gamma+2}},$$

γ, ϕ, K and C are constants, A_i is a number of pixels in an ith region, σ_i represents energy of the pixel values for the ith region, $\tilde{B}_i$ represents the number of bits available and α_i is a weighting factor incorporating importance of the region distortion.

17. A method according to claim 15 wherein the optimized quantization values for a selected region is derived as follows:

summing the energy in each of the regions to determine a total energy in the video image;

multiplying the total energy with an amount of energy in the selected region;

scaling the multiplied energies according to a scaling factor; and

squaring the scaled energies thereby generating the optimized quantization value for the selected region.

18. A method according to claim 17 wherein scaling the multiplied energies includes the following:

applying a first scaling factor proportional to the number of regions in the frame remaining to be quantized; and

applying a second scaling factor that varies for each region according to a total number of bits available for encoding the frame and a total number of bits already used to encode previous regions in the frame.

19. A method according to claim 18 including applying a third and fourth scaling factor, the third scaling factor modeling correlation statistics in the region and the fourth scaling factor representing overhead data in the encoded frame.

20. A method according to claim 19 including applying a fifth scaling factor proportional to a number of pixels in each region.

21. A method according to claim 15 wherein the energy in each region is proportional to a standard deviation for pixel values or a sum of the absolute values of the pixels in relation to an average of all pixel values in the same region.

22. A method according to claim 15 including predicting the total energy in the video image by taking the total energy for a previous video image.

23. A method according to claim 15 wherein the predicted optimum quantization values are reduced for the blocks having less energy and the predicted optimum quantization values are increased for the blocks having more energy.

24. A method according to claim 21 wherein the energy is adjusted by a scaling value for the pixels in intracoded regions, the scaling value characterized according to different K values representing correlation statistics for different types of coded regions.

25. An encoder for quantizing regions in video frames, comprising:
a circuit for detecting an amount of video information in one of the regions;

a quantizer controller assigning quantization values to each region that minimize an amount of predicted distortion in the video frames for a target bit value, the quantizer controller predicting an amount of distortion created in the video frames before the information in the region is actually quantized and adjusting the quantization values assigned to each region to minimize the predicted distortion according to a constraint that a total number of available bits for encoding the frames is equal to the target bit value; and

a quantizer quantizing the video information in the regions according to the adapted quantization values associated with the regions generated from the quantizer controller.

26. An encoder according to claim 25 including a transform circuit receiving the video image at an input and generating transform coefficients at an output, the quantizer quantizing the transform coefficients for each region according to the associated quantization values.

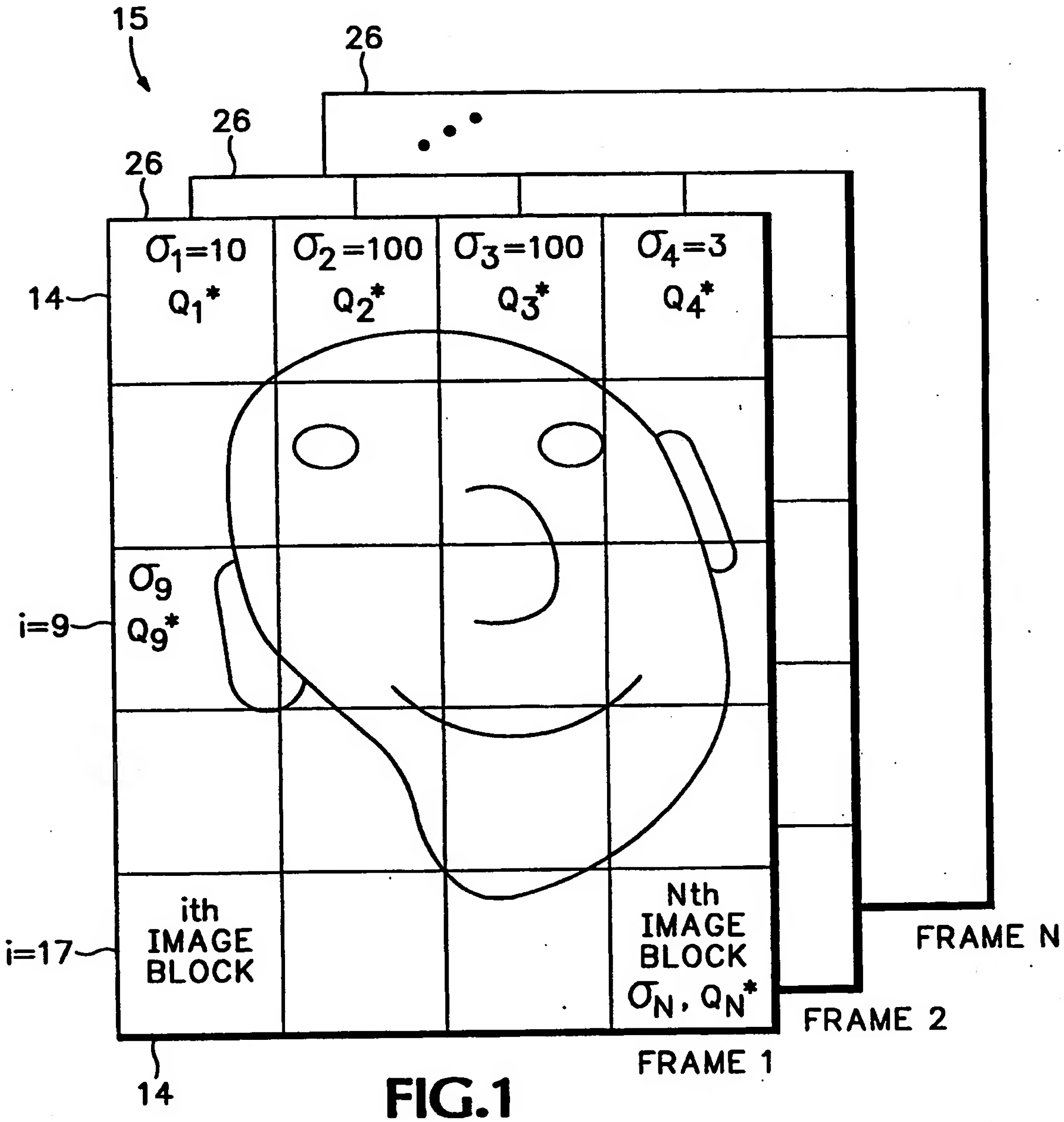

15
26
26
26
σ_1=10
Q_1^*
σ_2=100
Q_2^*
σ_3=100
Q_3^*
σ_4=3
Q_4^*
14
σ_9
Q_9^*
i=9
i=17
ith
IMAGE
BLOCK
Nth
IMAGE
BLOCK
σ_N, Q_N^*
14
FRAME N
FRAME 2
FRAME 1

FIG.1

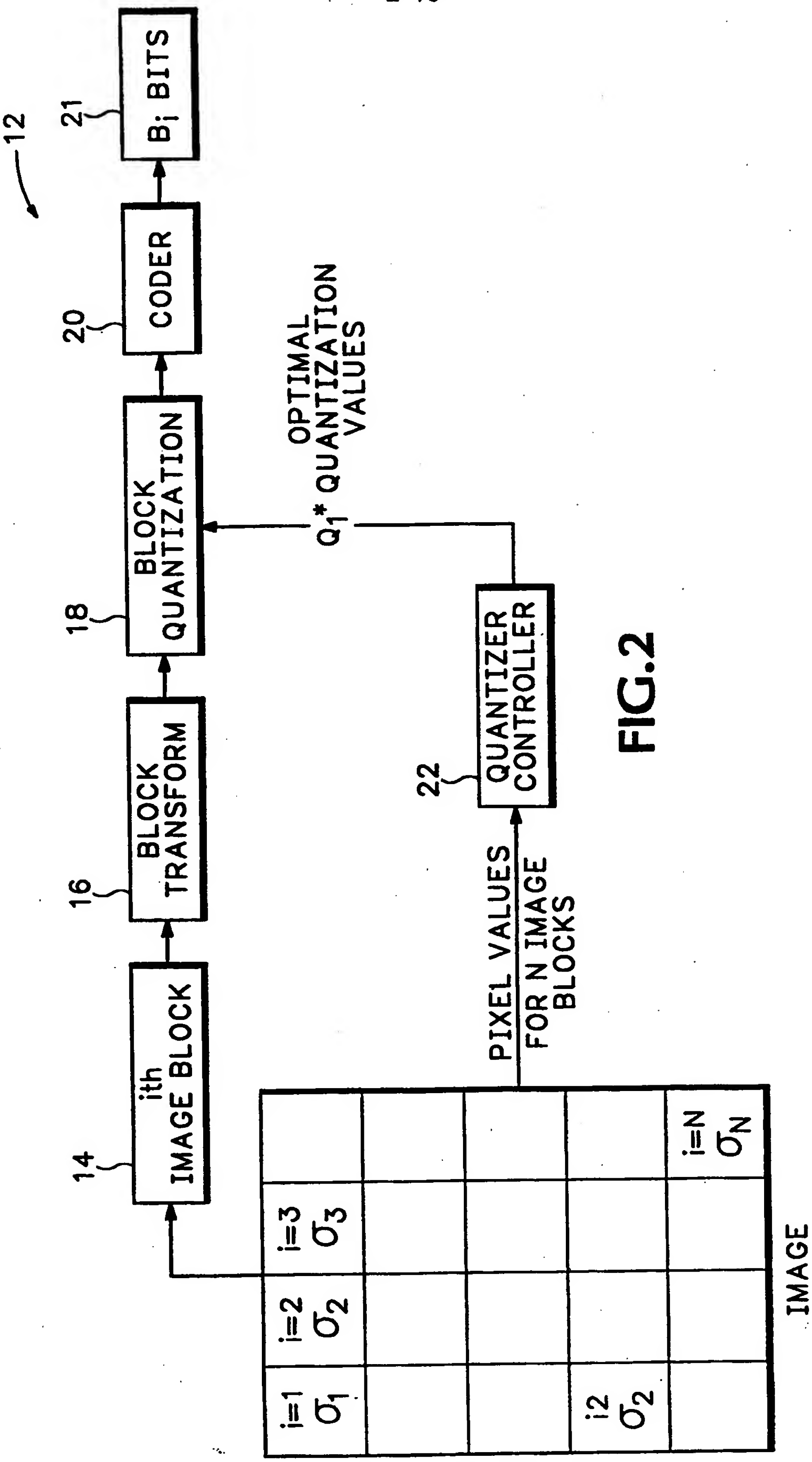

12
14
ith IMAGE BLOCK
16
BLOCK TRANSFORM
18
BLOCK QUANTIZATION
20
CODER
21
B_i BITS
OPTIMAL Q_1^* QUANTIZATION VALUES
22
QUANTIZER CONTROLLER
PIXEL VALUES FOR N IMAGE BLOCKS
i=1 σ_1
i=2 σ_2
i=3 σ_3
i2 σ_2
i=N σ_N
IMAGE

FIG.2

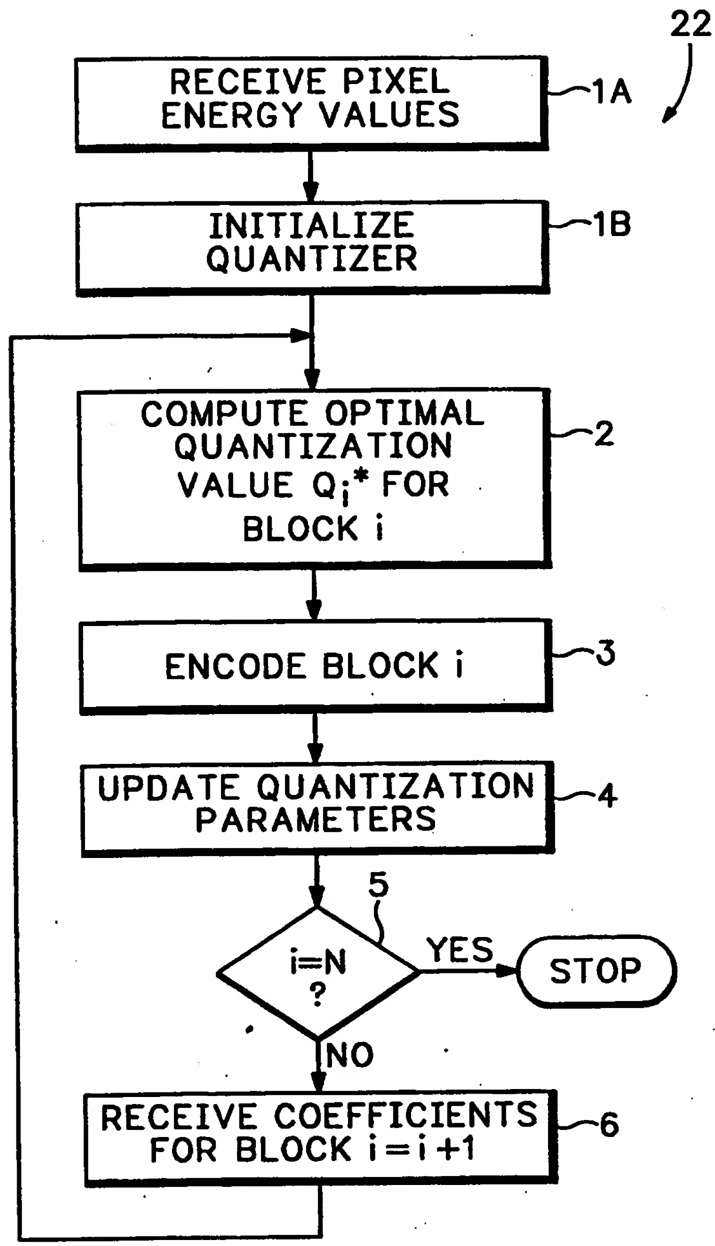

22
RECEIVE PIXEL ENERGY VALUES
1A
INITIALIZE QUANTIZER
1B
COMPUTE OPTIMAL QUANTIZATION VALUE Q_i* FOR BLOCK i
2
ENCODE BLOCK i
3
UPDATE QUANTIZATION PARAMETERS
4
5
i=N ?
YES
STOP
NO
RECEIVE COEFFICIENTS FOR BLOCK i=i+1
6

FIG.3

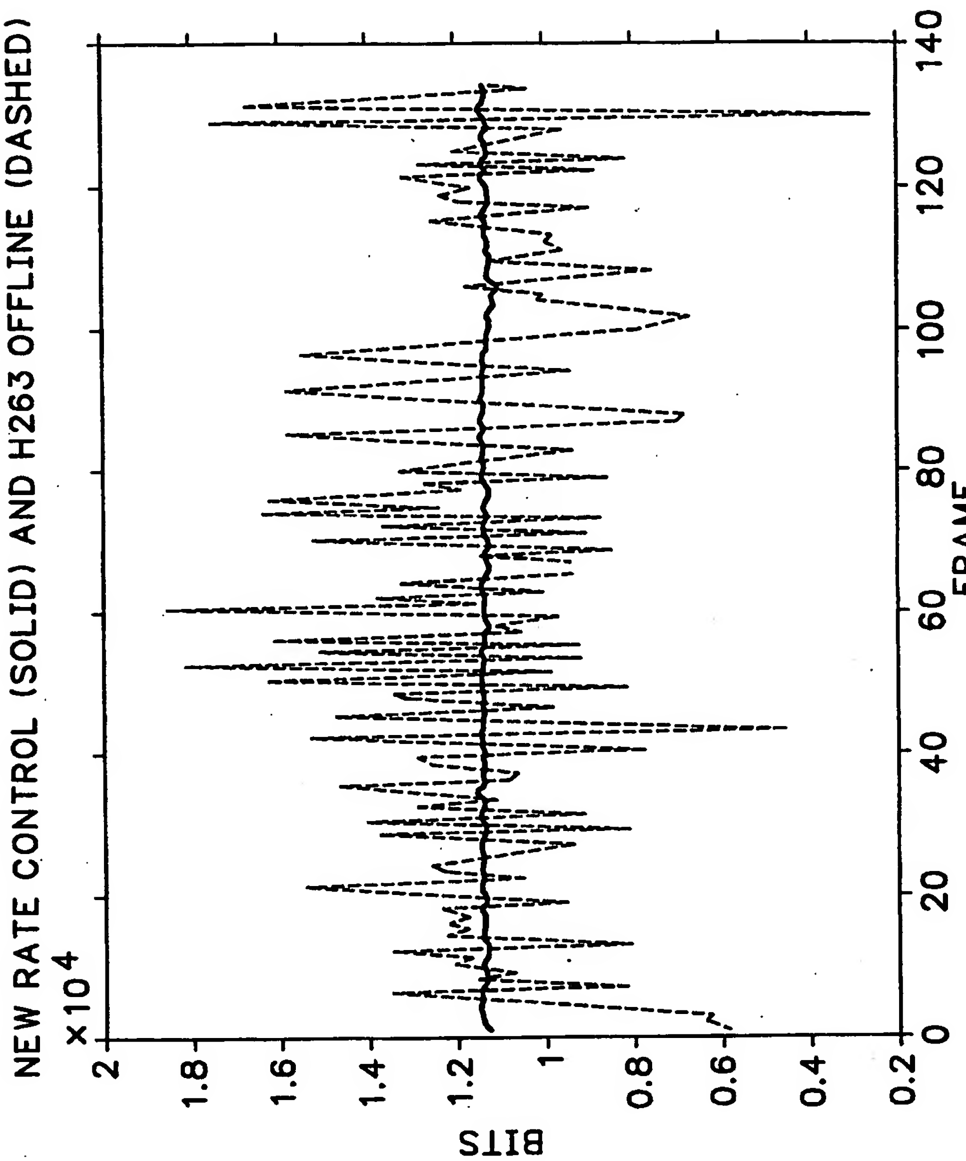
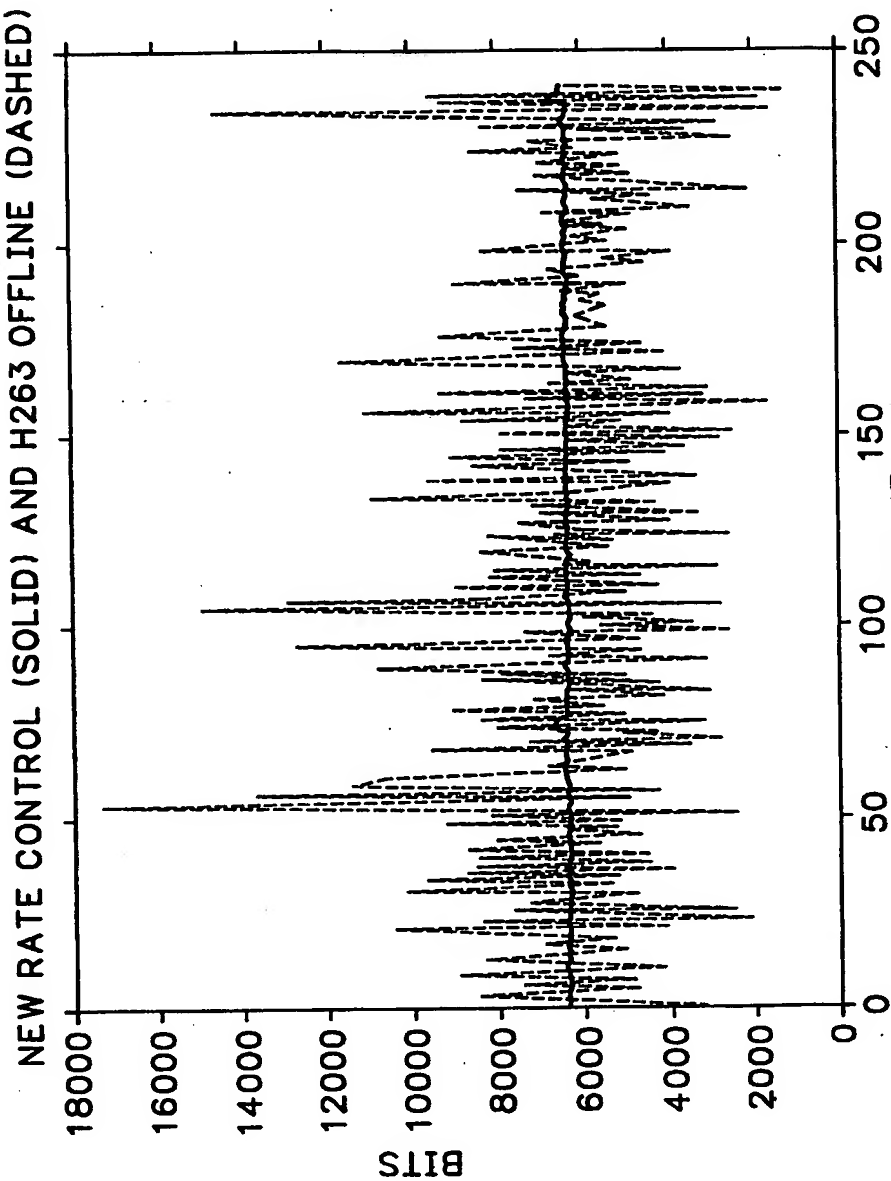
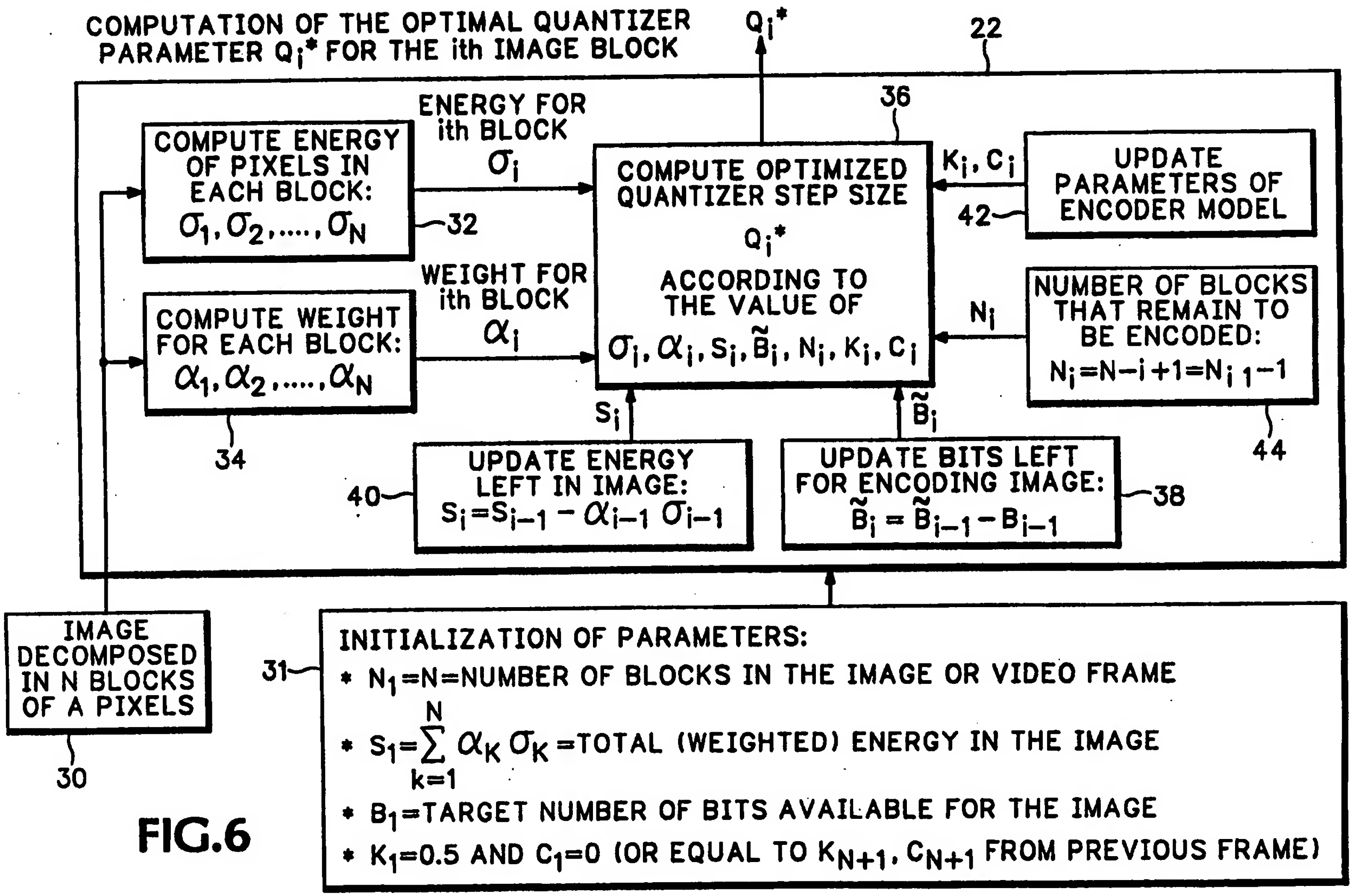

NEW RATE CONTROL (SOLID) AND H263 OFFLINE (DASHED)
×10^4
BITS
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
20
40
60
80
100
120
140
FRAME
FOREMAN

FIG.4



MOTHER AND DAUGHTER

FIG.5



COMPUTATION OF THE OPTIMAL QUANTIZER PARAMETER Q_i^* FOR THE ith IMAGE BLOCK
Q_i^*
22
COMPUTE ENERGY OF PIXELS IN EACH BLOCK: $\sigma_1, \sigma_2, \ldots, \sigma_N$
32
ENERGY FOR ith BLOCK σ_i
COMPUTE WEIGHT FOR EACH BLOCK: $\alpha_1, \alpha_2, \ldots, \alpha_N$
34
WEIGHT FOR ith BLOCK α_i
36
COMPUTE OPTIMIZED QUANTIZER STEP SIZE Q_i^* ACCORDING TO THE VALUE OF $\sigma_i, \alpha_i, S_i, \tilde{B}_i, N_i, K_i, C_i$
K_i, C_i
UPDATE PARAMETERS OF ENCODER MODEL
42
N_i
NUMBER OF BLOCKS THAT REMAIN TO BE ENCODED: $N_i = N - i + 1 = N_{i-1} - 1$
44
S_i
UPDATE ENERGY LEFT IN IMAGE: $S_i = S_{i-1} - \alpha_{i-1} \sigma_{i-1}$
40
$\tilde{B}_i$
UPDATE BITS LEFT FOR ENCODING IMAGE: $\tilde{B}_i = \tilde{B}_{i-1} - B_{i-1}$
38
IMAGE DECOMPOSED IN N BLOCKS OF A PIXELS
30
31
INITIALIZATION OF PARAMETERS:
* $N_1 = N$ = NUMBER OF BLOCKS IN THE IMAGE OR VIDEO FRAME
* $S_1 = \sum_{k=1}^{N} \alpha_K \sigma_K$ = TOTAL (WEIGHTED) ENERGY IN THE IMAGE
* B_1 = TARGET NUMBER OF BITS AVAILABLE FOR THE IMAGE
* $K_1 = 0.5$ AND $C_1 = 0$ (OR EQUAL TO K_{N+1}, C_{N+1} FROM PREVIOUS FRAME)

FIG.6